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## **Recasting Economics As If the Climate and Global Ecology Really Mattered**

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### **Abstract**

The current paradigm of global economics with exponential and continuous economic growth is unsustainable as far as Earth system ecology is concerned. To support the Earth system and boost sustainable development, a functional and operational linkage between global ecology and economics should be established – which we term ‘carbonomics’. The simple basis of ‘carbonomics’ is that the more fossil and non-fossil carbon one has as stocks, and not flows, of carbon, the richer one is. This opinion piece makes some suggestions about how we might establish such a balanced relationship.

### **Author Notes:**

John R Porter is an internationally known agricultural scientist with an expertise in agronomy, crop ecology and physiology, simulation modelling and food systems. From 2011 to 2014 he led the writing of the critically important chapter for the IPCC 5th Assessment in Working Group 2 on food production systems and food security. He has served or continues to serve on many national, regional and international public and private bodies concerned with agricultural research, education and development such as CGIAR committees; IPCC; International Crop Science Society; European Society for Agronomy; European Joint Research Programme on Food Security, Agriculture and Climate; Institut de la Recherche Agronomique (INRA) in France; US AgMIP and EU MACSUR joint program on agricultural and economic modelling and, most recently, The Barilla Foundation for Food and Nutrition.

Mark Howden is Director of the Climate Change Institute at the Australian National University. His work has focused on climate impacts and adaptation for systems we value: agriculture and food security, the natural resource base, ecosystems and biodiversity, energy, water and urban systems. He helped develop the national and international greenhouse gas inventories and has assessed sustainable ways to reduce emissions. Mark has partnered with many industry, community and policy groups via both research and science-policy roles and has over 400 publications. He has been a major contributor to the IPCC since 1991 now being a Vice Chair of IPCC Working Group 2.

Pete Smith is the Professor of Soils and Global Change at the Institute of Biological and Environmental Sciences at the University of Aberdeen (Scotland, UK), Science Director of the Scottish Climate Change Centre of Expertise (ClimateXChange) and Director of Food Systems for the Scottish Food Security Alliance-Crops. He leads the University of Aberdeen multi-disciplinary theme on Environment & Food Security. He is a Fellow of the Royal Society of Biology, a Rothamsted Research Fellow, a Fellow of the Institute of Soil Scientists, a Research Fellow of the Royal Society (London; 2008-2013), and a Fellow of the Royal Society of Edinburgh. He has led the writing of many chapters for the IPCC on the topic of land-based mitigation.

Michaela Schiller Stokholm is a postdoctoral fellow, investigating microbial communities associated with crop plants in response to various environmental conditions, including fungal diseases and the potential for botanical seed treatments to improve plant health and productivity. She became highly interested in agriculture and biological sciences during her travels in Latin America 20 years ago, where she realized how essential food security is for protection of the environment, in particular the tropical forests in poor developing countries. During her BSc and MSc studies in agronomy and biotechnology she has investigated plant pathogens and biological control organisms, while her PhD was about molecular plant nutrition in cereals. The plant microbiome and its importance for plant health and nutrient cycling in the soil, together with sequestration of carbon and how it could be linked to improving soil fertility and food security, as well as mitigation of climate change, is among her main interests and concerns.

**Keywords:** climate change, carbon standard, global economy, global ecology, carbon stocks, carbon sequestration

## Introduction

Both economy and ecology share the same ancient Greek language root or prefix: '*oikos*', which means house or home. While economics is a purely human invention that has no objective existence beyond the minds of women and men, physics exists whether or not there are people to believe in its laws. The 'laws' of neo-liberal economics, based on the continued exploitation and use of natural resources and fossil energy, are being increasingly challenged by the physical laws of thermodynamics – which, amongst other things, state that adding net energy to a closed system increases the system's temperature; an effect one can observe every time one makes a cup of tea. The system in question is the global atmospheric system. The extra net energy input comes from the effect of increasing trace gases in the atmosphere that leads to trapping of long-wave radiation and restricting its return to space, from which it came, thus increasing mean global temperature. Although they share the same '*oikos*' the main systemic difference between economics and ecology, and the main scientific reason for their conflict, is the fact that ecology is a zero-sum game, whilst economics in its current form is not. The ecological zero-sum game arises because of the finite amount of energy that enters the Earth system, thus setting an upper limit to the productivity of the global ecosystem. Economics being the creation of human minds has no such zero-sum game constraint and this is evidenced by the fact that the global economic growth rate is a positive relative rate – i.e. it is exponential. The question arises, for how long can the non-zero sum game of economics be based on the finite zero-sum game of global ecology?

We suggest that we can reconcile these two '*oikos*' by developing an economic system that values ecological carbon stocks higher than their flows and in which there are penalties for exploiting carbon and other stocks and rewards for not doing so. To transition to a non-fossil fuel based energy system, without wrecking the global economic system, requires that we must base our idea of economic value on the most valuable element on the planet - that is carbon. Concepts such as the low carbon economy, environmental economics and finance are however not new. In fact we are already deeply enrolled in the carbon economy with carbon pricing, regulations and taxes, including systems for carbon emissions trading of permits and credits (Newell *et al.* 2012). The current carbon market uses various emissions trading systems, each representing the right to emit a certain amount of greenhouse gas (GHG), which is equivalent in radiative warming potential of one tonne of CO<sub>2</sub> (Button 2008). The first carbon offset project was initiated in 1989 (Newell *et al.* 2012) and the framework of the carbon market to create monetary incentives to reduce carbon emissions and thereby mitigate global warming was then adopted in 1997 by the international community under the Kyoto Protocol of the UN Framework Convention on Climate Change (UNFCCC 1998). The Kyoto Protocol came first into force in 2005 and was then ratified by 191 states in 2010 (Dalsgaard 2013). Carbon has thus become a new type of commodity, although it already prior to climate change has been a fundamental part of the economy, particularly in terms of hydrocarbons such as coal, oil and gas (Dalsgaard 2013; Bridge 2010). Even though there is a huge concern about reduction of CO<sub>2</sub> and other carbon and non-carbon GHGs emissions, such as

HFCs (hydrofluorocarbons) and  $N_2O$ , concern and noble intentions are insufficient to prevent further increases in atmospheric GHG concentrations, radiative forcing and global warming (Stocker 2013). This requires us to consider the entire planetary carbon cycle and its link to the global economy. The carbon cycle comprises carbon stocks in ecological reservoirs such as soils, forests, oceans and the atmosphere together with fossil-based reserves (oil, coal, gas etc.) and the carbon flows between stocks. Instead of trading the rights to emit carbon into the atmosphere as the primary focus of the current carbon markets, much stronger economic incentives to mitigate climate change should be implemented, to prevent the serious consequences we are facing, if we do not succeed in keeping global warming below 2°C above pre-industrial levels (IPCC 2014). The idea of creating a stronger link between carbon and the economy by using carbon as a standard of value and even potentially as a currency has previously been discussed by Button (2008) and Dalsgaard (2013). To avoid dangerous climate change, a new global economic system should be invented. This would embed strong economic incentives to maintain current carbon stocks (both fossil and non-fossil), as well as strong incentives to sequester and thus grow terrestrial and biological carbon stocks by an amount more than the amount of carbon emitted to the atmosphere, in order to shift the main direction of the carbon flow, leading to a net reduction of carbon in the atmosphere and thereby mitigate further climate changes. This is critical in order to reach a steady-state equilibrium of carbon and non-carbon GHGs in the atmosphere (IPCC 2013) that will not endanger life on Earth. We term the discipline of making an explicit link between global ecology and economics to be ‘carbonomics’.

## Maintaining Carbon Stocks

Maintaining carbon stocks requires a new ecosystem based valuation of economies developed deliberately to value the maintenance of carbon and other ecological stocks higher in monetary terms, than their flows and in which there are penalties for exploiting carbon and rewards for not doing so, as well as rewards for carbon sequestration. One way to do this is to link currency value to carbon stocks, such that a currency’s value falls if a country’s net carbon stocks fall – a so-called carbon standard for the valuation of currency. Developing such a ‘saving- value’ paradigm would maintain the economic viability of current fossil fuel industries by valuing their unexploited fossil energy reserves and give them a window of opportunity to transition to becoming non-fossil based energy industries and thus a bridge to a non-fossil fuel global energy system. The robustness of knowledge of carbon stocks and flows would be positively related to their value, thus also providing incentive for effective monitoring. We must change thinking from the conventional economically comfortable ideas of carbon taxation, or credits, which have had little effect to date on reducing emissions, or even the idea of ‘pricing’ nature, to assessing the value of economics in environmental terms rather than the converse. This means that the environment should be the dominant and decisive partner in this relationship and not the afterthought. Such a redesign requires economists and ecologists who are prepared to think outside the conventional ‘box’, to create and analyse,

economic and resource-use models to essentially move onto a ‘carbon standard’ as a basis of economic value.

Prior to the Bretton Woods agreement in 1944 that introduced a new regulation of the international monetary system, the value of a currency was measured in gold stocks – the so-called ‘gold standard’, although markets still retreat into gold when the financial system is turbulent. What would a carbon-based economic system look like and what would be the consequences for the global economy and environment of moving onto a ‘carbon standard’ – *i.e.*, from one element in the Periodic Table (gold) to another (carbon)? These questions need a historical, a climate change and an environmentally focused analysis of the *modus operandi* of the Bretton Woods process – in terms of the intellectual processes, the instruments established, the modelling performed and the decision and governance process that gave it life and revolutionised the global economic system post-World War 2. We are at a time in our development as a species where we need to rethink the very foundations of the global economy, in the face of very serious consequences if we are neither brave nor inventive enough to rethink the relation between our global economic and ecological systems. A carbon-based economic system, would in addition to adding value to fossil fuel stocks, also add value to the preservation of non-fossil carbon stocks such as forests, perennial forms of farming and soil organic matter. Another way to frame this would be that each country is committed to maintain a given net level of carbon stocks, which means that it could use carbon flows to the extent that the net carbon stock is not decreased over time, but rather increased. On the contrary, net losses in carbon stocks would affect the carbon currency value of the country. In short, the basis of ‘carbonomics’ is that the more fossil and non-fossil carbon stocks one has, the richer one is.

### **Adding to Carbon Stocks**

Compared with the amount of carbon in the atmosphere, oceans account for about fifty times as much carbon, while terrestrial ecosystems store almost three times as much carbon, in which the largest carbon reservoirs are in soils (Ciais *et al.* 2013). Plants are the fundamental biological drivers of the conversion from atmospheric carbon into biomass and soils via photosynthesis. Soil fauna together with microorganisms are then responsible for the turnover and decomposition of carbon-rich compounds in the soil, obtained from root exudates of living plants, as well as from dead plant and animal substances, which eventually leads to formation of stable soil organic matter (humus) (Bot and Benites, 2005). A significant amount of soil organic carbon has been lost during conversion from natural to agricultural ecosystems. Restoring this lost carbon is a major challenge and requires agricultural practices that increase the stable fraction of the soil organic matter (Kirkby *et al.* 2014). Although agriculture significantly contributes to greenhouse gas emissions via carbon and non-carbon greenhouse gas emissions, there is a major potential to increase soil carbon through improvement of crop and grazing land management, restoration of degraded soils, as well as cultivation of cover crops (Smith *et al.* 2008; Peoplau and Don 2015). Rebuilding topsoils with organic matter would effectively translate into better soil fertility with improved soil structure, water infiltration and

moisture holding-capacity, and availability of essential plant nutrients, including nitrogen, phosphorus and sulphur (Berg and McClaugherty 2014). There is thus a strong alignment between enhancing carbon stocks and meeting the major challenge of future food security (Porter *et al.* 2013).

## **A Carbon-Based Transformation of the Global Economy**

In previous times the human trading system was largely a carbon transfer system (food, timber, fabric plus non-carbon or embodied carbon goods such as metals, gems etc.). People spent the vast majority of their income (or equivalent) on accessing these carbon forms either directly or indirectly. Life was tough for many. However in the last 100 years this outlay has dropped dramatically in the developed world (Wesley 2016), whilst it remains high in many developing countries where people/economies are much more strongly reliant on primary production. In developed countries, there is a close coupling of this decline in relative expenditure on carbon-based items such as food and the increasing reliance on fossil carbon for energy. Addressing climate change will require a decoupling of these different carbon economic elements (e.g. keeping food prices manageable or transport effective whilst reducing GHG emissions).

A fundamental issue is whether to view carbon as a commodity or as a currency (Button 2008; Porter and Wratten 2015), if the aim is to reduce the atmospheric concentration of the gas. Categorization as a commodity (like wheat or a metal) invites emission control methods such as carbon taxes or trading of the commodity – methods that have not generally yielded the desired outcomes of substantial reductions in carbon emissions. From an ecological viewpoint seeing carbon as a currency makes more sense in coupling global ecology to global economics. Such a transformation in outlook would make forests and soils resemble deposit accounts in a bank, referred to as an international carbon bank, and carbon would gain recognition from governments as a currency - as economic currencies do now. Such a development would link tangibly the global economy to global ecology with parallels to existing global 'Bretton Woods' institutions such as the IMF and the World Bank.

Although the above idea of creating an ecosystem based global economy is not completely novel, there is still a long way to go since this idea directly challenges conventional economic thinking about the nature of value and the value of nature. The form of economics that humans have practiced over time has not been static; the initial bartering of goods and services gave way to the use of tokens of value, as a means of easing the exchanges of goods and services between humans, and hence the invention of money and subsequently banking, which introduced virtual transactions. Historically, the form of economics has also been dictated by the social and political climate of the period. The birth of mercantilism and the European discovery of 'new lands' in the 17<sup>th</sup> and 18<sup>th</sup> centuries engendered the development of banks and insurance markets in a largely laissez-faire system; in the 20<sup>th</sup> century supply-side regulation of economies gave way to the demand-driven state-stimulated policies of Keynes and the New Deal – this being in response to the overriding issue

of mass unemployment in the late-1920s and 1930s. So economics, at its core, has been mostly, and should be a conceptually flexible human animation that responds to the socio-political issues of the time, in a way that improves the human lot for as many people as possible. As Keynes remarked in his *General Theory* - in economic terms, it is more important to be generally right than precisely wrong. More stable and long-term valuation of currencies could be expected if the value would be based on carbon stocks (which change only slowly) rather than flows, and might even prevent currency speculation that induces uncertainty for businesses and governments. Instead of financial stock-markets there would be carbon stock-markets, of which fluctuations would depend on whether carbon is released to or captured from the atmosphere. Of course this would require development of effective, unbiased, transparent and cheap monitoring and evaluation systems, as well as a way to deal with changes in carbon stocks that are not under management and policy influence (e.g. wildfires or warming that reduces soil carbon or a pathogen that wipes out a species – like the Dutch elm disease). One consequence of linking carbon stocks to economic valuation is that it allows a link to be made between such a policy and the Kaya identity (Bennetzen *et al.*, 2015), especially the first two elements that relate emissions to the type of fuel used to produce energy and the energy used per unit of GDP. Economic theory and experience suggests that an incentive to maintain carbon stocks against an economic penalty for not doing so would of itself lead to lower emissions per unit energy used and to lower energy use per unit GDP – i.e. be a drive to higher energy efficiencies in the economic process. The picture of which are the rich and which are the poor countries of the world might also change radically under a carbon-stock valuation system of money and might additionally encourage competition among different countries, in order to boost their currency value by protecting carbon stocks and re-stocking carbon into their biological reservoirs. Farmers who improve soil fertility and biodiversity by sequestering carbon into their soils could be rewarded by earning carbon credits, which is already a possibility for farmers in Australia (Koch *et al.* 2015). Based in part on these experiences from Australia, the French Minister of Agriculture launched the ‘4 per 1000’ carbon sequestration initiative for agriculture at the climate conference COP 21 in 2015. The ‘4 per 1000’ initiative aims at increasing soil carbon by four parts per thousand per annum, to reconcile food security and climate change (Koch *et al.* 2015). At a citizen level, reflecting the carbon footprint in food prices would have a huge impact on consumer choices. For instance, meat from animals that have been fed with fodder such as soya grown in areas that used to be rainforest, and then transported across the ocean, might be very expensive compared to meat from animals that have been used for nature conservation by grazing permanent grasslands, in a way that maximises the increase of soil organic matter.

## Conclusions and Perspectives

Sustainable development has many dimensions and these are reflected in the recently adopted sustainable development goals (UNDP, 2016). However, underpinning many of these goals is the need to link global ecology with global economics in a deliberate and operational way. These questions need, amongst other elements, a historical analysis of the



*modus operandi* of the post-World War 2 Bretton Woods process. We are at a time in our development as humans, where we need to do this again – in the face of very serious consequences if we do not rethink the relation between our global economic and ecological system, to prevent global warming from reaching over 2°C above pre-industrial levels. In contrast to the above, conventional economics deals with carbon emissions by a variety of economic tools such as taxes, trading schemes, licences to emit, discounting methods of adaptation to impact mitigation of climate change. These methods assume that those approaches that have worked in the past, such as regulating the emissions of CFCs (chlorofluorocarbons) to the atmosphere because of their detrimental effects on ozone chemistry, can be replicated for carbon emissions. But such analogues do not exist for several reasons; the first is that there were readily available technical ‘fixes’ to the ozone issue – this is partly the case for carbon but to a much smaller degree. The second is that technical fixes work when the environmental problem is caused by a commodity and, in the case of CFCs, this is a useful denomination whereas carbon may be better treated as a currency (Button 2008). The final reason is more fundamental, in that use of fossil carbon is inimically bound psychologically to our current model of economics – but as JM Keynes wrote in the Preface to his ‘General Theory of Employment, Interest and Money’ – ‘*The difficulty [in novel economic thinking] lies, not in the new ideas, but in escaping from the old ones which ramify, for those brought up as most of us have been, into every corner of our minds.*’ Similarly prior to the Bretton Woods conference, the US Treasury Official Harry White, who was JM Keynes’ opposite number, wrote the following to describe the political shortcomings of the US State Department to the negotiations that were precursor to Bretton Woods: ‘*Where modern diplomacy calls for swift and bold action, we engage in cautious negotiation...where we should be dealing with all embracing economic, political and social problems, we discuss minor trade objectives and small national advantages... we must substitute, before it is too late, imagination for tradition, generosity for shrewdness, understanding for bargaining, toughness for caution and wisdom for prejudice.*’ These quotes are as relevant today, in setting the necessary radical agenda to deal with fossil carbon, as they were in setting the path from the misery of the 1930s to the relative peace and prosperity we have enjoyed since 1944. The macro-challenge of climate change requires the macro-response of rethinking our global economic system to incorporate carbon fully into the latter and mitigating climate change by an ecosystem based valuation of the global economy.

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